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(54) Hospital bed.

(57) A bed comprises a frame structure with an upper body supporting bed frame part 32 and a thigh supporting bed frame part 36, said bed frame parts being inclination adjustably articulated to a support frame 16. The bed further comprises adjustment means 80, 82 for adjusting the inclination angle of each of said bed frame parts 32, 36, and inclination angle determining means in 88 for determining an inclination angle a1, a2 of each of the bed frame parts 32, 36, angular distance determining means in 88 for determining an angular distance a_d between said bed frame parts 32, 36 and safety means for preventing the angular distance a_d from falling below a predetermined value a_{min} in case at least one of said adjustment means 80, 82 is actuated.

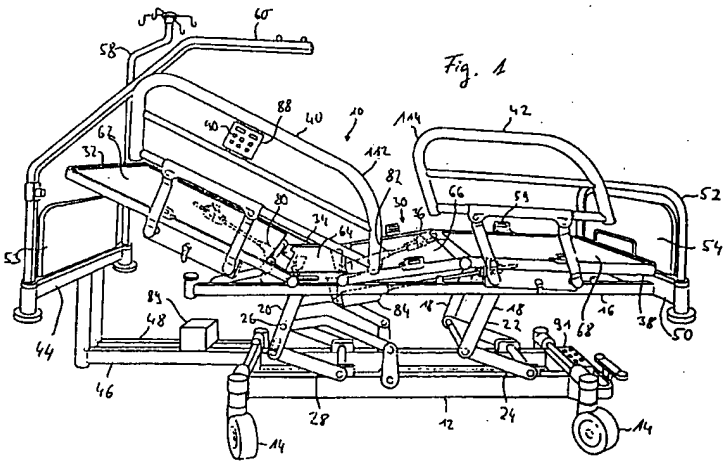

Fig. 1

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The present invention relates to a bed, in particular a hospital bed, comprising a bed frame structure, said bed frame structure comprising a height and/or inclination adjustable support frame, said support frame defining a longitudinal axis of said bed and a support plane, an upper body supporting bed frame part, articulated to said support frame in a hip supporting region thereof so as to be swingable about an axis substantially perpendicular with respect to said longitudinal axis and lying within said support plane and a thigh supporting portion, articulated to said support frame in said hip supporting portion thereof so as to be swingable about an axis substantially perpendicular with respect to said longitudinal axis and lying within said support frame, for adjusting a lying and/or sitting positioning of said bed, adjustment means associated with each of said bed plane parts for adjusting the inclination angle of each of said bed frame parts with respect to said support frame.

Such a hospital bed, for example, is known from the German patent publication DE-3808408-C2. This hospital bed comprises an upper body supporting bed frame part articulated to a support frame and a thigh supporting bed frame part also articulated to the support frame. The upper body supporting bed frame part and the thigh supporting bed frame part are adjustable in inclination by respective adjustment means, which, for example, are cylinder piston devices or a threaded rod and a worm wheel which may be operated by hand. The inclination angles of the respective bed frame parts of this known bed are adjustable independently of each other so that the problem arises that upon improper adjustment of the inclination angle of at least one of the bed frame parts with respect to the support frame, a patient lying on the bed is positioned in an ergonomically improper lying or sitting position, which, in some cases, might lead to damage to the patient's health. Further, there arises the problem that side rail members which, in some cases, can be mounted to the respective bed frame parts in order to prevent the patient from falling out of bed when moving in an undesired or improper manner might interfere with each other in the adjacent end portions thereof. This problem arises in particular if the respective bed frame parts are inclined with respect to the supporting frame in high degree.

Therefore, it is the object of the present invention to provide a bed in which, upon adjustment of the inclination angle of at least one of the bed frame parts, the resulting lying or sitting positioning of the bed is always ergonomically advantageous for the patient lying in the bed, and which prevents the mutual interference of side rail members if such members are attached to the respective bed frame parts.

According to the invention this problem is solved by the bed according to the preamble part of claim 1, further comprising inclination angle determining means associated with each of said bed frame parts for determining an inclination angle of each of said bed frame parts, angular distance determining means for determining an angular distance between said upper body supporting bed frame part and said thigh supporting bed frame part, and safety means for preventing the angular distance from entering an undesired angle range, in case at least one of said adjustment means is actuated for adjusting the inclination angle of the respective bed frame part.

The bed of the present invention eliminates the risk of the angular distance between the upper body supporting bed frame part and the thigh supporting bed frame part becoming too small and, thus, secures, upon any adjusting operation of the bed frame parts, an ergonomically advantageous sitting or lying positioning. Additional side rail members attached to the bed frame parts do not interfere with each other even if at least one of the bed frame parts is lifted to a high extent.

For controlling the operation of the adjustment means the bed according to the present invention further comprises control means. With these control means the hospital personnel or the patient lying on the bed is able to easily adjust the inclination angle of the respective bed frame parts. The control means may comprise control mode selection means for selecting a plurality of different control modes of said control means. This allows selecting different control modes, which, for example, comprise a mode in which the inclination angle of the upper body supporting bed frame part has priority over the inclination angle of the thigh supporting bed frame part or vice versa. The control mode selection means may comprise a first control mode selection means for selecting a knee-up control mode in which said thigh supporting bed frame part 36 is lifted and in which the upper body supporting bed frame part is lowered from its inclination position in case said angular distance falls below a predetermined minimum value, in order to maintain said predetermined minimum value of said angular distance between said upper body supporting bed frame part and said thigh supporting bed frame part. When the knee-up control mode is selected, the positioning of the thigh supporting bed frame part has priority over the positioning of the upper body supporting bed frame part, which is particularly advantageous if the patient lying on the bed wants his thighs or legs to be positioned in a specific position, or if, owing to a specific injury the thighs or legs have to be positioned in a specific position. The control mode selection means may further compris a second

control mode selection means for selecting a head-up control mode in which said upper body supporting bed frame part 32 is lifted and in which the thigh supporting bed frame part is lowered from its inclination position, in case said angular distance falls below a predetermined minimum value, in order to maintain said predetermined minimum value of said angular distance between said upper body supporting bed frame part and said thigh supporting bed frame part. With the second control mode selection means the patient lying on the bed is able to give the positioning of the upper body supporting bed frame part priority over the positioning of the thigh supporting bed frame part in case the patient wants his upper body to be positioned in a specific upright position, for example for eating, without the risk of the angular distance between the upper body supporting bed frame part and the thigh supporting bed frame part becoming too small.

In order to avoid frequent changes of the inclination positions of the bed frame parts, in case one of the bed frame parts is adjusted in angular position, it is proposed lowering said upper body supporting bed frame part and/or said thigh supporting bed frame part only if said inclination position is a maximum inclination position of said upper body supporting bed frame part and/or said thigh supporting bed frame part.

Alternatively, it is possible to lower the respective bed frame parts only in case the inclination position is an inclination position of said upper body supporting bed frame part and/or said thigh supporting bed frame part within a predetermined angle range in the region of a maximum inclination position of said upper body supporting bed frame part and/or said thigh supporting bed frame part.

In order to provide easy access to the control means for a patient lying on the bed it is proposed arranging the control means on a side rail member connected to said upper body supporting bed frame part.

Some patients' injuries absolutely require that the bed be positioned in a predetermined position which is not to be changed afterwards. In order to prevent readjustment of the angular positions of the bed frame parts by the patient it is proposed providing lockout control means for disabling controlling of the operation of the adjustment means via the control means, these lockout control means being operable by the hospital personnel only.

A swinging movement of at least the upper body supporting bed frame part requires additional space which has to be generated in the region of the articulation of the upper body supporting bed frame part to the support frame. This space, in particular, is necessary for the mattress which might becom pressed in the curved region thereof as well as for the patient's hip part, which now comes into a sitting position. Therefore, it is proposed articulating said upper body supporting bed frame part and said thigh supporting bed frame part to a hip supporting bed frame part fixedly mounted to said supporting frame, the swinging axis of the upper body supporting bed frame part being movable in said longitudinal direction upon swinging movement of said upper body supporting bed frame part so as to move towards said swinging axis of said thigh supporting bed frame part, in case said swinging movement of said upper body supporting bed frame part is a lowering movement, and away from said swinging axis of said thigh supporting bed frame part, in case said swinging movement of said upper body supporting bed frame part is a lifting movement.

The linear movement of the articulation axis of the upper body supporting bed frame parts also provides additional free space between side rail members which might be mounted to the respective bed frame parts, thus preventing the side rail members from mutually interfering with each other upon a swinging movement of at least the upper body supporting bed frame part and, additionally, avoiding the risk of a patient's arm or finger getting squeezed between the side rail members upon lifting the bed frame parts.

As a further aspect, which is independent of the aspect mentioned above, the present invention is directed to a side rail arrangement, said side rail arrangement comprising a first side rail member mounted to a first bed frame part in a lateral portion thereof and having an axis of elongation extending in essential parallel to a plane defined by said first bed frame part, a second side rail member mounted to a second bed frame part in a lateral portion thereof and having an axis of elongation extending in essential parallel to a plane defined by said second bed frame part, said first bed frame part and said second bed frame part being articulated to a support frame of said bed about respective first and second axis for adjusting a lying and/or sitting positioning of said bed, said first side rail member and said second side rail member constituting a safety wall member of said bed, an axial end portion of said first side rail member positioned adjacent to an axial end portion of said second side rail member and/or said axial end portion of said second side rail member being configured so as not to interfere with each other upon a swinging movement of at least one of said first and second bed frame parts.

The side rail arrangement according to the present invention eliminates the risk of the first and second side rail members interfering with each other upon a swinging movement of the respective bed frame parts. The side rail arrangement accord-

ing to the present invention further provides sufficient free space between th first and second side rail members in every inclination position of the first and second bed frame parts in order to prevent a patient's arm or fingers positioned between the side rail members during the swinging movement from being injured.

Preferably, the first and second side rail members are swingably mounted to said first and second bed frame parts, respectively, so as to be swingable between a raised position in which said first and second side rail members in common constitute said safety wall member, and a lowered position in which said first and second side rail members allow lateral access to the bed. This allows moving the respective side rail members between the respective positions, thus obviating the necessity of dismounting the respective side rail members if free lateral access to the bed is required.

If the axial end portion of the first side rail member comprises an inclined portion having an outline inclined with respect to said longitudinal axis of said first side rail member, said outline being inclined in an upward direction away from said second side rail member, it is secured that upon a lifting movement of one of the bed frame parts no edge portions of the side rail members abut against each other and, thus, would lock the swinging movement of the bed frame parts. The invention thus allows a large swinging range of the bed frame parts.

Preferably, the inclined portion has an approximately circular outline with a centre of said approximately circular outline lying in the region of said first axis.

Therefore, upon a swinging movement of the first bed frame part the edge of the first side rail member moves along a circular line without any portion of the edge of the first side rail member being brought nearer to the second side rail member.

Additionally, the end portion of the second side rail member may comprise an inclined portion having an outline inclined with respect to said longitudinal axis of said second side rail member, said outline being inclined in an upward direction towards said first side rail member. Together with the embodiment of the first side rail member this specific embodiment of the second side rail member ensures that the safety wall member constituted by the first and second side rail members is a substantially closed wall member without an excessive gap between the first and second side rail members even if the respective bed frame parts are not inclined with respect to the support frame.

Preferably, the first and second side rail members are provided on each side of the bed. Thereby, a patient is prevented from falling out of bed even if the bed is not arranged adjacent to a wall.

The first bed frame part may be an upper body supporting bed frame part and the s cond bed frame part may be a lower leg supporting bed frame part articulated to a thigh supporting bed frame part, said thigh supporting bed frame part being directly articulated to said support frame. In this configuration, the first and second side rail members can always follow the inclination adjustment movements of the upper body supporting bed frame part and the thigh supporting bed frame part and, therefore, in every inclination position constitute a safety wall member directly adjacent to the surface the patient is positioned on.

In the following, preferred embodiments of the present invention are described in detail with respect to the appending drawings, in which:

- fig. 1 is a perspective side view of a hospital bed according to the present invention;
- fig. 2 is a plan view showing respective bed frame parts of the bed according to the present invention;
- fig. 3 is a diagrammatic side view of the respective bed frame parts in differently inclined positions;
- fig. 4 is a diagrammatic side view corresponding to the side view of figure 3 showing the bed frame parts in a different inclination position;
- fig. 5, 6 are diagrammatic side views showing a kind of adjusting the inclination of an upper body supporting bed frame part; and
- fig. 7 is a flow chart of the adjustment procedure for the bed of the present invention.

In figure 1 a hospital bed is generally denoted by 10. The hospital bed comprises a lower support structure 12 with ground wheels 14 for easily moving the bed 10 on the floor. A support frame 16 is height adjustably and inclination adjustably supported by said lower support structure 12 via respective pairs of support arms 18 and 20. Each of the support arms 18, 20 comprises two arm parts 22, 24, 26, 28, being articulated to each other with one end portion thereof and articulated to the lower support structure (arm portions 24, 28) and to the support frame 16 (arm portions 22, 26) with another end thereof, respectively. The height and/or the inclination of the support frame 16 with respect to the lower support structure 12 is adjusted by known devices (not shown in the figur s), e.g., a threaded rod and electric adjustment motor associated with each of the arm parts 18, 20.

The support frame 16 carries a bed frame 30 constituted of a plurality of bed frame parts. These

bed frame parts comprise a bed frame part 32 supporting th upper body of a patient lying on a bed, a bed frame part 34 for supporting a patient's hip, a bed frame part 36 for supporting a patient's the upper leg portion (thigh portion) and a bed frame part 38 for supporting a patient's lower leg portion. Bed frame parts 32 and 36 are articulated with one end portion to the support frame 16, respectively, so as to enable adjustment of inclination of these bed frame parts 32, 36 with respect to support frame 16. Additionally, the articulated end portion of the frame part 32 is linearly movable in a longitudinal direction of the support frame 16 upon swinging movement of the frame part 32. Thus, the lying or sitting position of the patient may be adjusted.

The lower leg supporting bed frame part 38 is articulated with one end thereof to another end of the upper leg supporting bed frame part 36 so as to enable adjustment of the knee inclination angle of the patient. The inclination of the various articulated bed frame parts may be adjusted by any known adjustment means, such as a cylinder piston device, a threaded rod and an electric adjustment motor. The adjustment means for adjusting the inclination of the respective bed frame parts are shown schematically in figure 1. A first adjustment means comprising a threaded rod and an electric adjustment motor is fixed with one end portion thereof with respect to the support frame 16 and is fixed with its other end portion with respect to the upper body supporting bed frame part 32. By adjusting the effective length of the first adjustment means 80 the inclination of the upper body supporting bed frame part with respect to the support frame 16 can be adjusted.

A second adjustment means 82 for adjusting the inclination angle of the thigh supporting bed frame part 36 with respect to the support frame 16 is fixed with respect to the support frame 16 with one end portion thereof and is fixed with respect to the thigh supporting bed frame part 36 with its other end portion. By adjusting the effective length of the second adjustment means 82 the inclination angle of the thigh supporting bed frame part 36 can be adjusted.

A third adjustment means 84 is fixed with respect to the support frame 16 with one end portion thereof and is fixed with respect to the lower leg supportion bed frame part 38 with another end portion thereof. By adjusting the effective length of the third adjustment means 84 the inclination angle of the lower leg supporting bed frame part 38 with respect to the thigh supporting bed frame part 36 and, therefore, the knee inclination angle can be adjusted.

As will be described later on, the operation of the various adjustment means employed for adjusting the inclination angle of the different bed frame parts with respect to the supporting frame 16 and the operation of th adjustment means for adjusting the height and the inclination of the support frame 16 with respect to the lower support structure 12 is controlled by control means 88, 89 fixedly mounted to the bed 10.

Further, the bed frame parts 32 and 38 carry side rail members 40 and 42 in order to prevent the patient from falling out of bed. The side rail members 40 and 42 are swingably mounted to the respective bed frame parts 32 and 38 so as to be swingable between a working position (illustrated in fig. 1) in which the side rail members 40 and 42 prevent the patient from falling out of bed and also prevent lateral access to the bed, and a rest position (not illustrated in fig. 1), in which the side rail members 40, 42 are swung towards the ground in order to enable lateral access to the bed. As can be seen in figure 1, a controller 88 of the control means 88, 89 is attached to the side rail member 40 which is mounted to the upper body supporting bed frame part 32. Thus, a patient lying on the bed is able to adjust the various inclination positions from his lying or sitting position in bed simply by touching one of a plurality of control buttons 90 provided on the controller 88.

The control means 88, 89 are electrically connected to all of the adjustment means shown in fig. 1 by respective signal lines (not illustrated in the figures), and also all of the adjustment means and the control means 88,89 may be connected to a source of electric energy (an accumulator, etc.) via respective lines (not illustrated in the figures).

Although not shown in the figures, side rail members may be provided on each side of the bed in order to prevent a patient from falling out of bed when moving in an undesired manner, even if the bed is not arranged adjacent to a wall. Further, a controller 88 may be attached to each of the side rail members disposed on every side of the bed in order to allow the patient to adjust the inclination irrespective of the patient's position in the bed.

As further shown in fig. 1, a plurality of holding devices 59 is mounted to the bed frame parts 32, 36, 38. These holding devices 59 serve for supporting respective mattress supporting panel parts 62, 66, 68 with respect to the respective bed frame parts 32, 36 and 38. The mattress supporting panel parts, in turn, carry a mattress (not illustrated in fig. 1).

The holding devices 59 further serve for laterally fixing the mattress with respect to the respective bed frame part.

The bed further comprises a head side end bar 44 being connected to the lower support structure 12 by mounting rods 46, 48. A foot side end bar 50 is directly fixed to the support frame 16. The head

side end bar 44 and the foot side end bar 50 are arranged with respect to a longitudinal axis of the bed 10 so as to extend substantially perpendicularly in a lateral direction with respect to the longitudinal axis at the respective head side end and foot side end of the bed 10.

The head side end bar 44 and foot side end bar 50 serve for carrying a plurality of different accessories. As shown in figure 1, these accessories may comprise a substantially U-shaped manoeuvering bar 52 and a foot side panel 54 carried by the foot side end bar 50, and a head side panel 56, a pole 58 for carrying containers for infusion liquid, etc., a patient helper carrying a grip (not illustrated in fig. 1) for helping the patient lying in the bed change his position in the bed. Of course, a plurality of further accessories not illustrated in the figures may be carried by the respective end bars 44, 50, and it is also possible to attach the pole 58, for example, to the foot side end bar 50 and to attach a substantially U-shaped manoeuvering bar 52 to the head side end bar 44, in case the patient helper 60 is not necessary.

The functioning of the bed of the present invention upon adjusting the inclination angle of the different bed frame parts will now be described with respect to figures 3, 4 and 7.

The control means 88, 89 shown in figure 1 comprise the controller 88, e.g., a switch panel with a plurality of control buttons 90, as already mentioned, as well as a control box 89 comprising a microcomputer with a central processing unit (not illustrated in the figures) and being fixed to the lower support structure 12. The controller 88 is connected to the control box 89 via signal lines (not illustrated in the figures). The central processing unit is supplied with a first angular position signal indicative of the inclination angle of the upper body supporting bed frame part with respect to the support frame 16, a second angular position signal indicative of the inclination angle of the thigh supporting bed frame part 36 with respect to the support frame 16. Further, a third angular position signal indicative of the inclination angle of the lower leg portion supporting bed frame part 38 with respect to the thigh supporting bed frame part 36 may be supplied to the central processing unit. The respective angular position signals may be provided by angular position sensors (not illustrated) associated with each of the bed frame parts, by rotation position sensors associated with each of the adjustment means 80, 82, 84 and indicating the effective length of the respective adjustment means and, therefore, the inclination angle of the respective bed frame parts, or the like. The adjustment procedure will be described in accordance with the flow chart of figure 7.

First, in a step S1, the microcomputer within the control box 89 calls for determination as to whether one of the adjustment means 80, 82 has been activated. If none of the adjustment means has been activated, the processing procedes to a return step S19, and the processing of the flow chart of figure 7, which is repeated with a predetermined frequency, is terminated. If the answer is "yes" in step S1, it is detected that one of the adjustment means 80, 82 has been activated for adjusting the inclination of the respective bed frame parts. The respective adjustment means may be activated by one of the control buttons 90, for example, a lift- or a lower-button for lifting or lowering the respective bed frame part. Then a step S3 determines the inclination angle a_1 of the upper body supporting bed frame part 32 and the thigh supporting bed frame part 36 from the respective first and second angular position signals. Following the step S3, a step S5 determines the angular distance a_d between the upper body supporting bed frame part 32 and the thigh supporting bed frame part 36. As can be seen in figure 4, the angular distance a_d is the angle enclosed between the upper body supporting bed frame part 32 and thigh supporting bed frame part 36, whereas the inclination angles a1 and a2 of the upper body supporting bed frame part 32 and the thigh supporting bed frame part 36 are the angles between the support frame 16 and the respective bed frame parts.

The angular distance a_d may be calculated by the microcomputer using the following equation (I)

$$a_d = 180° - a_1 - a_2 \qquad (I)$$

Then a step S7 compares the angular distance a_d with a minimum angular distance a_{dmin}. For securing an ergonomically advantageous positioning of a patient the minimum angular distance a_{dmin} may for example be 85°. In case $a_d \geq a_{dmin}$ the processing proceeds to the return step S19 followed by the termination of the processing.

If, however, in step S7 it is determined that $a_d < a_{dmin}$, then it is determined that the angular distance between the upper body supporting bed frame part 32 and the thigh supporting bed frame part 36 has entered a region in which an ergonomically advantageous position of the patient lying or sitting on the bed cannot be secured any longer.

In this case, a step S9 asks whether a knee-up control mode has been selected. This means that the patient lying on the bed has chosen the knee-up control mode by pressing one of the control buttons 90 of the controller 88. The knee-up control mode is a control mode in which the inclination position of the thigh supporting bed fram part 36

has priority over the inclination position of the upper body supporting bed frame part 32. Such a control mode may be selected by the patient if he wants his thighs to take a predetermined position. If the answer is "yes" in step S9, a step S15 calls for a determination whether the upper body supporting bed frame part is in a predetermined inclination position. Such a predetermined inclination position may be the maximum inclination of the upper body supporting bed frame part 32 with respect to the support frame 16 and may be, for example, 70°. Alternatively, this predetermined inclination position may be a position within a predetermined angle range in the region of the maximum inclination position.

If the answer is "no" in step S15, which means that the upper body supporting bed frame part is not in its maximum position or in the region of its maximum inclination position, the processing proceeds to the return step S19 without taking any measures for lowering the inclination of the upper body supporting bed frame part. This is done so, since, even if upon adjusting the inclination of the thigh supporting bed frame part 36 the angular distance a_d falls below the minimum value a_{dmin}, it is presumed that a_d will not fall below a_{dmin} to an excessive extent, since the upper body supporting bed frame part 32 is not raised to its maximum inclination position and, additionally, the inclination angle a_2 of the thigh supporting bed frame part is also restricted to a maximum value, which, for example, may be 55°.

However, if in step S15 it is decided that the upper body supporting bed frame part 32 is in the predetermined inclination position, in a step S17 the upper body supporting bed frame part 32 is lowered in order to maintain the minimum value of the angular distance a_d. The upper body supporting bed frame part 32 may be lowered by an incremental angle value in every repetition of the processing shown in figure 7 until it is determined in step S7 that a_d is no longer smaller than the minimum angular distance a_{dmin}. For lowering the upper body supporting bed frame part 32, the controller outputs a respective drive signal to the adjustment means 80 associated with the bed frame part in every repetition of the processing of fig. 7.

If the answer is "no" in step S9, which means that the knee-up control mode has not been selected, it is determined that a head-up control mode has been selected by the patient by pressing one of the respective control buttons 90. In the head-up control mode, the inclination adjustment of the upper body supporting bed frame part 32 has priority over the adjustment of the inclination of the thigh supporting bed frame part 36, which, for example, is the case if the patient wants to take a predetermined sitting position with a substantially upwardly directed upper body.

Then a step S11 calls for a determination whether the thigh supporting bed frame part 36 is in a predetermined inclination position. As already mentioned with respect to the upper body supporting bed frame part 32, such a predetermined inclination position may be the maximum inclination position of the thigh supporting bed frame part in which, for example, the angle a_2 may be 55°.

Alternatively, such a predetermined inclination position may be an inclination position within an inclination angle range in the region of the maximum inclination angle of the thigh supporting bed frame part 36.

If the answer is "no" in step S11, the processing proceeds to the return step S19. This means that the thigh supporting bed frame part is not positioned in the predetermined inclination position, and, therefore, no steps for lowering the same are necessary. As has already been mentioned with respect to step S15, it is not necessary to lower the thigh supporting bed frame part 36 in case a_d falls below a_{dmin}, as the thigh supporting bed frame part is not inclined to its maximum extent and, therefore, it is presumed that a_d will not fall below a_{dmin} to an excessive extent.

If the answer is "yes" in step S11, then in a step S13 the thigh supporting bed frame part 36 is lowered in order to maintain the minimum angular distance a_{dmin} between the upper body supporting bed frame part 32 and the thigh supporting bed frame part 36 followed by the return step and the termination of the processing. The thigh supporting bed frame part 36 may be lowered by an incremental angle value with every repetition of the processing of figure 7 until it is determined in step S7 that a_d is not smaller than a_{dmin}, in the same manner as described with respect to step 17.

As can be seen in the description of the flow chart of figure 7 and figures 3 and 4, the bed of the present invention always secures an ergonomically advantageous sitting or lying position for a patient placed on the bed without the risk of the angular distance between the upper body supporting bed frame part and thigh supporting bed frame part becoming too small upon adjustment of the respective bed frame parts, which might lead to injuries or, at least, uncomfortableness for the patient.

Although not described in detail here, the control means 88, 89 may further comprise means for adjusting the lower leg portion supporting bed frame part 38 with respect to the thigh supporting bed frame part 36 always in an optimum manner in case the inclination of the thigh supporting bed frame part 36 is adjusted. Further, the controller 88 may comprise a control button for allowing a patient to adjust the inclination of the lower leg por-

tion supporting bed frame part 38 with respect to the thigh supporting bed frame part 36.

Alternatively to the preferred embodiment described above, the time sequence of step S7 and the steps S9 to S17 may be changed. Further, it is also possible to omit steps S11 and S15.

The control means 88, 89 of the bed of the present invention may further comprise means for selecting a plurality of other control modes. Such a control mode can be, for example, a control mode in which, if the upper supporting bed frame part 32 is raised from a flattened, substantially horizontally directed position, the thigh supporting bed frame part 36 rises in the same manner. When the upper body supporting bed frame part has reached a predetermined inclination position (e.g., a_1 = 16°) the thigh supporting bed frame part 36 stops and, therefore, remains in an inclination position in which its inclination angle a_2 corresponds to the predetermined inclination angle (e.g., 16°). The upper body supporting bed frame part 32 will continue to rise until the respective control button is released. Upon a subsequent lowering of the upper body supporting bed frame part the thigh supporting bed frame part is also lowered if the inclination angle a_1 of the upper body supporting bed frame part 32 falls below the predetermined angle (e.g., 16°). This control mode leads to a particularly relaxed sitting or lying position of the patient and thus increases the comfort of the person lying on the bed. Further, with this control mode a person lying in the bed is prevented from sliding towards the foot end of the bed when the upper body supporting bed frame part 32 is lifted.

The bed according to the present invention further comprises a lockout control means 91 which is positioned with respect to the bed in a position in which a patient lying on the bed has no access to the lockout control means 91. The lockout control means 91 serves for locking operation of the controller 88, in case a patient has to be placed in a predetermined lying or sitting position and should not have the possibility to readjust his position. The lockout control means may be arranged at the lower support structure 12, for example as illustrated. The lockout control means 91 may also comprise respective control buttons for controlling the respective angular positions of the bed frame parts and of the support frame and may also comprise a microcomputer for carrying out the control processing for monitoring and controlling the angular distance a_d when adjusting the inclination of at least one of the bed frame parts.

As can best be seen in figures 3 to 6, the articulation axis 90 of the upper body supporting bed frame part 32 carries out a linear movement when the inclination of the upper body supporting bed frame part 32 is adjusted. In particular, the linear movement of the articulation axis 90 is of such a kind that when the upper body supporting bed frame part 32 is lifted the articulation axis 90 moves in a direction D (cf. fig. 6) away from the thigh supporting bed frame part 36 in order to create sufficient space in the hip supporting region of the bed.

Thus, an excessive deformation of a mattress lying on the bed and being curved upon lifting the upper body supporting bed frame part 32 may be avoided and, additionally, the space for positioning the hip region of the patient is increased.

For this reason an articulation arm 92 is pivotally fixed with an end portion 96 thereof to a structural member 94 which is fixedly secured to the support frame 16. With a second end portion 98 the articulation arm 92 is articulated to an intermediate portion 33 of the upper body supporting bed frame part 32.

The adjustment means 80 comprises a threaded rod 100 which can be rotated by an electric motor 102. The electric motor 102 is articulated to the structural member 104 by a housing portion thereof. The structural member 104 is fixed with respect to the support frame 16. A sleeve 108 is provided with an internal thread and is screwed on the threaded rod 100. Upon rotation of the threaded rod 100 the internal threaded sleeve 108 is moved in a longitudinal direction of the rod 100. A connecting rod 110 is fixedly mounted to the upper body supporting bed frame part 32 with one end portion thereof and is articulated to the sleeve 108 with an other end thereof.

Starting from a position as shown in fig. 5, upon a movement of the sleeve 108 in a direction to the left in fig. 5, i.e., away from the electric motor 102, the upper body supporting bed frame part 32 is also pushed to the left in fig. 5 by the connecting rod 110 articulated to the sleeve 108. However, as articulation arm 92 with its end 96 is fixed to the structural member 94 so as to be only swingable, the movement of the upper body supporting bed frame part 32 to the left in fig. 5 leads to a raising of the articulation arm 92 and, therefore, also to a swinging movement of the upper body supporting bed frame part 32 about the articulation axis 90. This leads to a positioning of the respective structural members, as shown in fig. 6. In this position the upper body supporting bed frame part is supported by the articulation arm 92 in the intermediate portion thereof, thus leading to a stable configuration even in a raised position of the upper body supporting bed frame part 32.

The electric motor 102, which, together with the threaded rod 100 constitutes the adjustment means 80, however, may be positioned in a manner differing from that shown in figs. 5 and 6. In order to allow an inclination of the upper body

supporting bed fram part even to a higher extent the adjustment means 80 may be positioned in a more inclined positioned with r spect to the hip supporting bed fram part 34, and, therefore, to the support frame 16.

Shifting the articulation axis 90 of the upper body supporting bed frame part leads to a further advantage, which can be seen in fig. 1. Adjusting the inclination of the respective bed frame parts might lead to the problem of the side rail members 40, 42 abutting against each other with their end portions 112, 114, thereby locking a further inclination movement of the bed frame parts. However, moving the articulation axis 90 of the upper body supporting bed frame part 32 away from the thigh supporting bed frame part 36 also moves side rail member 40 mounted to the upper body supporting bed frame part 32 away from side rail member 42 mounted to the thigh supporting bed frame part 36 via the lower leg portion supporting bed frame part 38, thus providing sufficient free space between the end portions 112, 114 of the respective side rail members 40, 42 upon a swinging movement of the bed frame parts.

Additionally, the side rail members 40, 42 are contoured so as to assist such a providing of sufficient free space.

As can be seen in fig. 1, the end portion 112 of side rail member 40 is inclined with respect to a longitudinal axis of said side rail member 40 so as to extend in an upwards direction away from the end portion 114 of side rail member 42. Particularly the end portion 112 has a substantially circular outline with the circle centre lying in the region of the articulation axis 90. Therefore, upon a swinging movement of the upper body supporting bed frame part 32 about the articulation axis 90, irrespective of the linear movement of the articulation axis 90, there are no parts of the side rail member 40 which move towards the end portion 114 of side rail member 42, which also avoids an abutment of end portion 112 against end portion 114.

Alternatively, the adjustment means 80 may comprise any adjustment means adapted for adjusting the inclination of the respective bed frame part, e.g., a cylinder piston device, etc.

As can also be seen in fig. 1, the end portion 114 of side rail member 42 is inclined with respect to a longitudinal axis of side rail member 42 in an upward direction and towards the end portion 112 of side rail member 40. Together with the specific contour of the outline of the end portion 112 this leads to a safety wall constituted by the side rail members 40, 42, which is substantially closed and which avoids an excessive gap between the side rail members 40, 42, yet, the swinging movement of the respective bed frame parts is not obstructed by the side rail members 40, 42.

The bed of the present invention allows a patient placed on the bed to easily control the inclination of various bed frame parts without running the risk that upon an erroneous activation of any one of the adjustment means for adjusting the inclination of the bed frame parts the bed frame parts come into an inclination position with respect to each other in which the patient may suffer pain or may even be injured. This safety system of the present invention in combination with the particular design of the side rail members mounted to the bed also provides that no structural members of the bed may interfere with each other upon adjusting the inclination of one of the bed frame parts. Automatic monitoring and controlling of the angular distance between the respective bed frame parts to a suitable value enables even persons who are not familiar with handling such technical equipment to properly adjust and correct inclination of the respective bed frame parts with respect to each other.

It should be noted that the specific values of the various angles given above are only a selection from a plurality of angle values and combinations of angle values which are suitable for positioning a patient in an ergonomically advantageous position.

Claims

1. A bed, in particular a hospital bed, comprising a bed frame structure, said bed frame structure comprising
   - a height and/or inclination adjustable support frame (16), said support frame (16) defining a longitudinal axis of said bed and a support plane,
   - an upper body supporting bed frame part (32), articulated to said support frame (16) in a hip supporting region thereof so as to be swingable about an axis (90) substantially perpendicular with respect to said longitudinal axis and lying within said support plane, and a thigh supporting portion (36), articulated to said support frame (16) in said hip supporting portion thereof so as to be swingable about an axis substantially perpendicular with respect to said longitudinal axis and lying within said support plane, for adjusting a lying and/or sitting positioning of said bed (10),
   - adjustment means (80, 82) associated with each of said bed frame parts (32, 36) for adjusting the inclination angle a_1, a_2 of each of said bed frame parts (32, 36) with respect to said support frame (16),

   characterized by further comprising

- inclination angle determining means (in 88) associated with each of said bed frame parts (32, 36) for determining an inclination angl a_1, a_2 of each of said bed frame parts (32, 36),
- angular distance determining means (in 88) for determining an angular distance a_d between said upperbody supporting bed frame part (32) and said thigh supporting bed frame part (36), and
- safety means (in 88) for preventing the angular distance a_d from entering an undesired angle range, in case at least one of said adjustment means (80, 82) is actuated for adjusting the inclination angle a_1, a_2 of the respective bed frame part (32, 36).

2. Bed according to claim 1, further comprising control means (88, 89) for controlling the operation of said adjustment means (80, 82).

3. Bed according to claim 2, said control means (88, 89) further comprising control mode selection means (90) for selecting a plurality of different control modes of said control means (88).

4. Bed according to claim 3, said control mode selection means (90) comprising a first control mode selection means (90) for selecting a knee-up control mode in which said thigh supporting bed frame part (36) is lifted and in which the upper body supporting bed frame part (32) is lowered from its inclination position in case said angular distance a_d falls below a predetermined minimum value a_{dmin}, in order to maintain said predetermined minimum value a_{dmin} of said angular distance a_d between said upper body supporting bed frame part (32) and said thigh supporting bed frame part (36).

5. Bed according to one of claims 3 or 4, said control mode selection means (90) comprising a second control mode selection means (90) for selecting a head-up control mode in which said upper body supporting bed frame part (32) is lifted and in which the thigh supporting bed frame portion (36) is lowered from its inclination position in case said angular distance a_d falls below a predetermined minimum value a_{dmin}, in order to maintain said predetermined minimum value a_{dmin} of said angular distance a_d between said upper body supporting bed frame part (32) and said thigh supporting bed frame part (36).

6. Bed according to one of claims 4 or 5, said upper body supporting bed frame part (32) and/or said thigh supporting bed frame part (36) being lowered only in case said inclination position is a maximum inclination position of said upper body supporting bed frame portion and/or said thigh supporting bed frame portion.

7. Bed according to one of claims 4 or 5, said upper body supporting bed frame part (32) and/or said thigh supporting bed frame part (36) being lowered only in case said inclination position is an inclination position of said upper body supporting bed frame part (32) and/or said thigh supporting bed frame part (36) within a predetermined angle range in the region of a maximum inclination position of said upper body supporting bed frame part (32) and/or thigh supporting bed frame part (36).

8. Bed according to one of claims 2 to 7, said control means (88) being arranged on a side rail member (40) connected to said upper body supporting bed frame part (32) or said thigh supporting bed frame part (36).

9. Bed according to one of claims 2 to 8, further comprising lockout control means (91) for disabling controlling of the operation of the adjustment means (80, 82) via the control means (90), said lockout control means being operable by the hospital personnel only.

10. Bed according to one of claims 1 to 9, said upper body supporting bed frame part (32) and said thigh supporting bed frame part (36) being articulated to a hip supporting bed frame part (34) fixedly mounted to said supporting frame (16), the swinging axis (90) of the upper body supporting bed frame part (32) being movable in said longitudinal direction upon swinging movement of said upper body supporting bed frame part (32) so as to move towards said swinging axis of said thigh supporting bed frame part (36) in case said swinging movement of said upper body supporting bed frame part (32) is a lowering movement, and away from said swinging axis of said thigh supporting bed frame part (36), in case said swinging movement of said upper body supporting bed frame part (32) is a lifting movement.

11. Side rail arrangement particularly for use in a bed according to one of claims 1 to 10, said side rail arrangement comprising a first side rail member (40) mounted to a first bed frame part (32) in a lateral portion thereof and having an axis of elongation extending in essential

parallel to a plane defined by said first bed frame part (32), a second side rail member (42) mounted to a second bed frame part (38) in a lateral portion thereof and having an axis of elongation extending in essential parallel to a plane defined by said second bed frame part, said first supporting bed frame part (32) and said second bed frame part (38) being articulated to a support frame (16) of said bed about respective first and second axis for adjusting a lying and/or sitting positioning of said bed, said first side rail member (40) and said second side rail member (42) constituting a safety wall member of said bed, an axial end portion (112) of said first side rail member (40) positioned adjacent to an axial end portion (114) of said second side rail member (42) and/or said axial end portion (114) of said second side rail member (42) being configured so as not to interfere with each other upon a swinging movement of at least one of said first and second bed frame parts.

12. Bed according to claim 11, said first and second side rail members (40, 42) being swingably mounted to said first bed frame part (40) and said second bed frame part (42) so as to be swingable between a raised position in which said first and second side rail members (40, 42) in common constitute said safety wall members, and a lowered position in which said first and second side rail members (40, 42) allow lateral access to the bed.

13. Bed according to one of claims 11 or 12, said axial end portion (112) of said first side rail member (40) comprising an inclined portion having an outline inclined with respect to said longitudinal axis of said first side rail member (40), said outline being inclined in an upward direction away from said second side rail member (42).

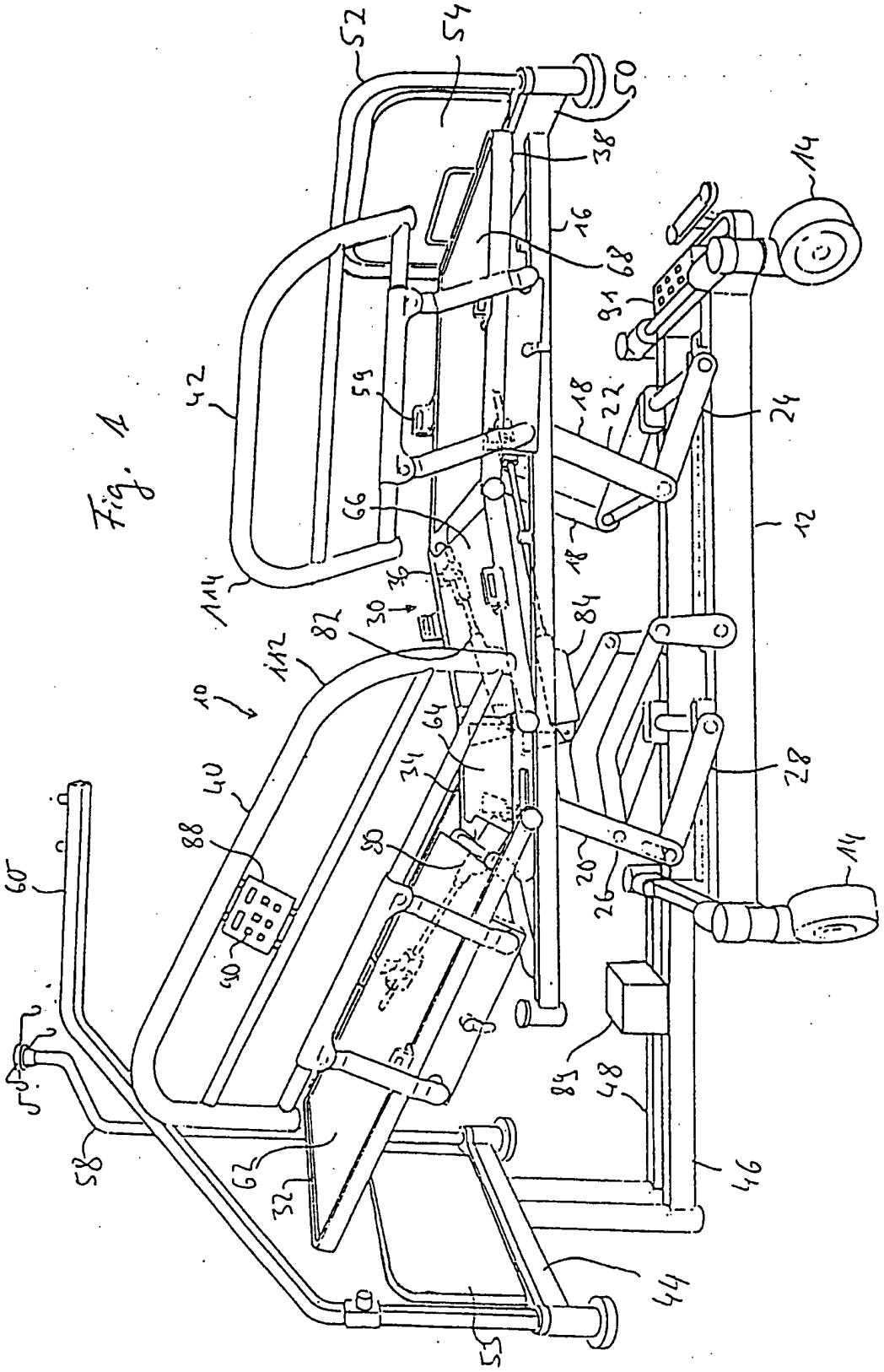
14. Bed according to claim 13, said inclined portion having an approximately circular outline, with a centre of said approximately circular outline lying in the region of said first axis (90).

15. Bed according to one of claims 11 to 14, said axial end portion (114) of said second side rail member (42) comprising an inclined portion having an outline inclined with respect to said longitudinal axis of said second side rail member (42), said outline being inclined in an upward direction towards said first side rail member (40).

16. Bed according to one of claims 11 to 15, said first and second side rail members (40, 42) being provided on each side of said bed.

17. Bed according to one of claims 11 to 16, said first bed frame part (32) being an upper body supporting bed frame part (32), and said second bed frame part (38) being a lower leg portion supporting bed frame part (38) articulated to a thigh supporting part (36), said thigh supporting part (36) being directly articulated to said support frame (16).

Fig. 1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114
18
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112
10
64
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44
55

FIG. 2

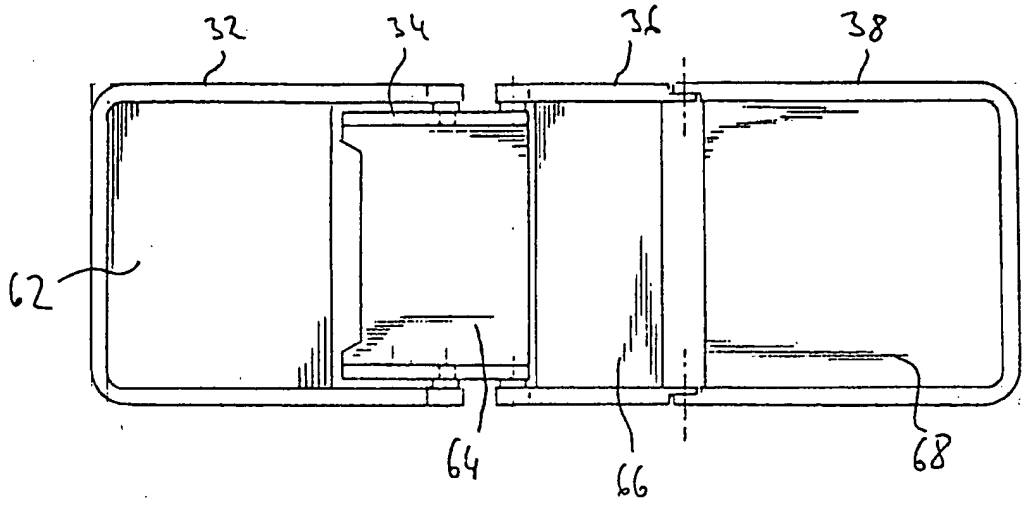


FIG. 3

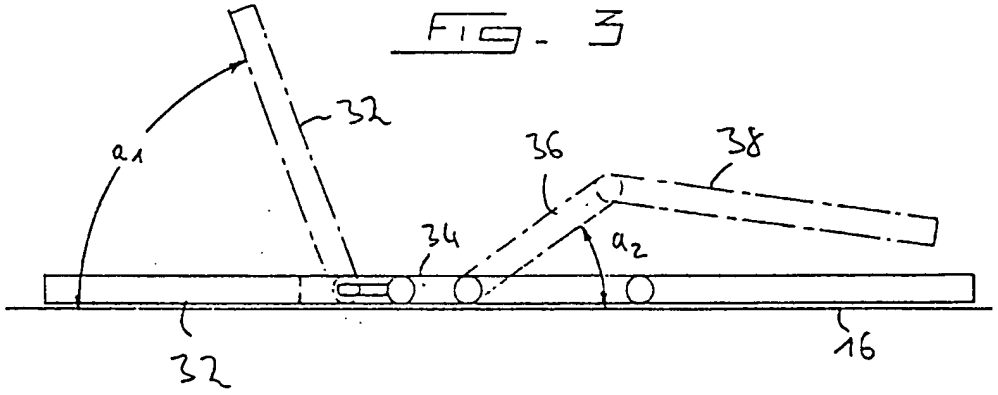


FIG. 4

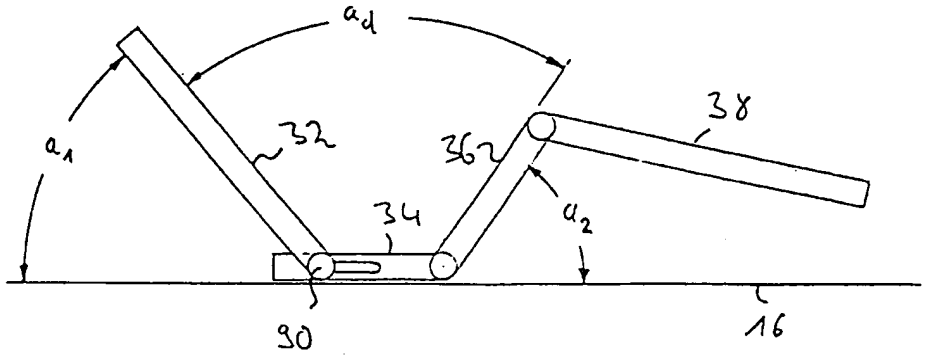


FIG - 5

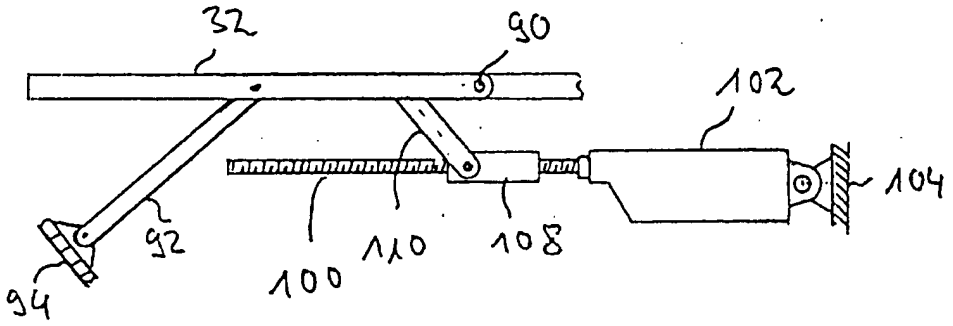
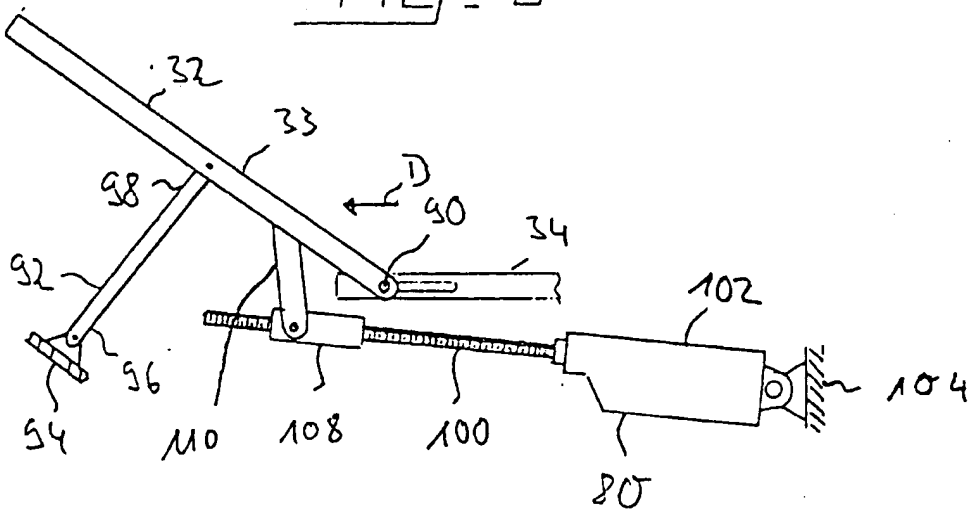

32
90
102
104
92
94
100
110
108

FIG - 6


32
33
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98
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34
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102
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104
94
110
108
100
80

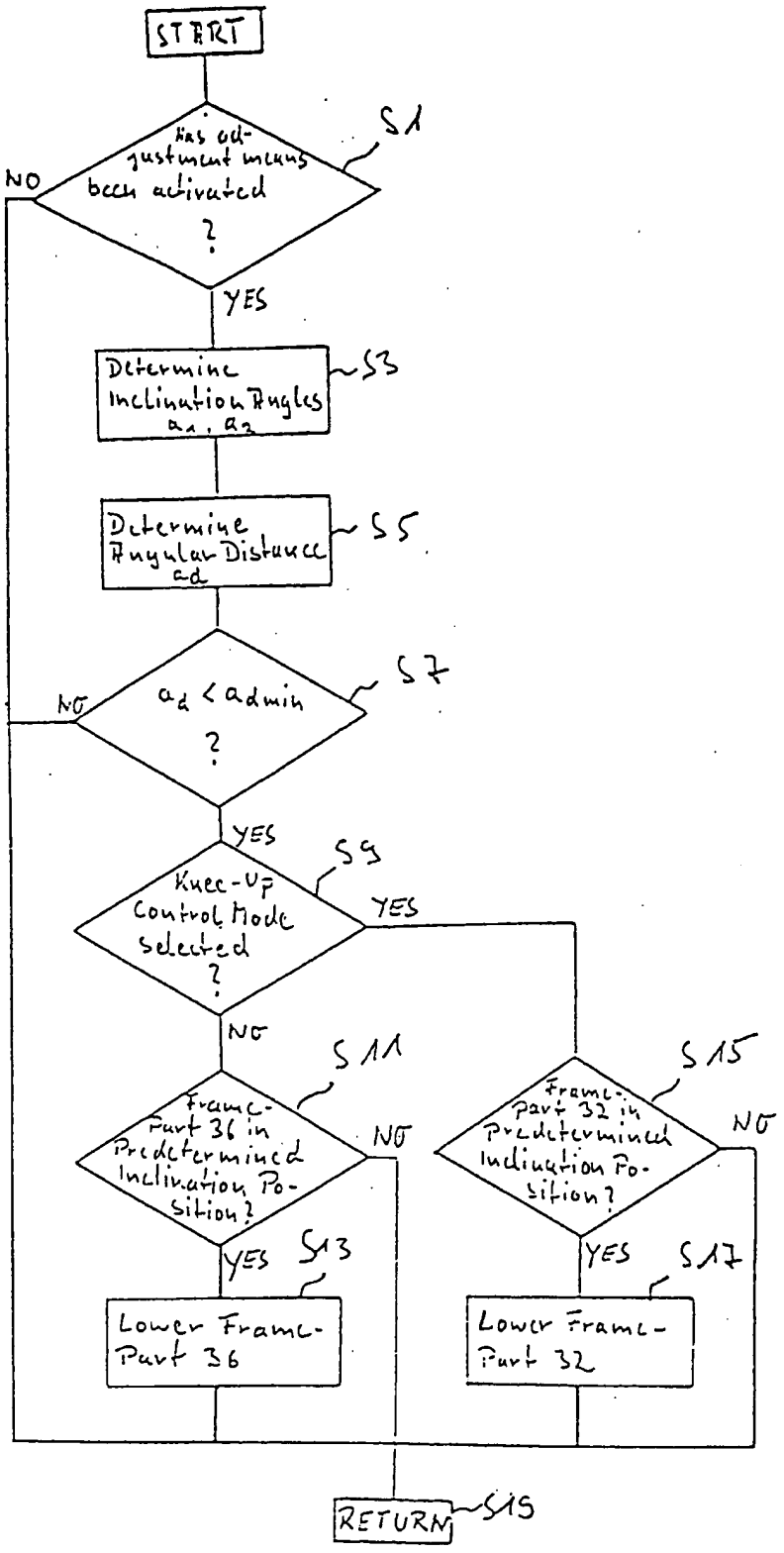
START
Has adjustment means been activated ?
S1
NO
YES
Determine Inclination Angles α_1, α_2
S3
Determine Angular Distance α_d
S5
$\alpha_d < \alpha_{min}$?
S7
NO
YES
Knee-Up Control Mode selected ?
S9
YES
NO
Frame-Part 36 in Predetermined Inclination Position?
S11
NO
YES
Lower Frame-Part 36
S13
Frame-Part 32 in Predetermined Inclination Position?
S15
NO
YES
Lower Frame-Part 32
S17
RETURN
S19

Fig. 7